ATTACHMENT II

MODEL DOMAIN SELECTION

Table of Contents

List of Figures

Nomenclature

ADEQ	Arizona Department of Environmental Quality
AERMOD	AMS/EPA MODel
ASU	Arizona State University
CMAQ	Community Multiscale Air Quality Model
EDAS	Enhanced Data Acquisition System
HYSPLIT	Hybrid Single-Particle Langrangian Integrated Trajectory
ISC	Industrial Source Complex
MCAQD	Maricopa County Air Quality Division
MSL	Mean Sea Level
MSL	Mean Sea Level
NOAA	National Oceanic & Atmospheric Administration
PM-10	Particulate Matter 10 microns in diameter or smaller
SLAMS	State and Local Air Monitoring Sites
TEOM	Tapered Element Oscillating Microbalance
UAM	Urban Airshed Model
UTC	Universal Transverse Mercator

1. Model Domain Selection

The following steps were considered in selecting the domains for AERMOD and rollback modeling:

- PM-10 nonattainment area boundaries
- Location of meteorological and air quality monitoring sites
- Distribution of major emissions sources
- Deposition and concentration of pollutants
- Previous PM-10 studies

Selection of the modeling domain takes into consideration all of these factors, as explained below.

1.1 PM-10 Nonattainment Area Boundaries

A 3,000 square mile area of Maricopa and Pinal Counties is a Serious nonattainment area for PM-10. The nonattainment area is located in a valley at an elevation of 1,105 feet above mean sea level (MSL) and is completely surrounded by mountains. The Salt River/South Mountains are located on the southern border of the study area and rise to an elevation of 2,507 feet above MSL. To the northwest, the Phoenix Mountains rise to an elevation of 2,310 feet above MSL. The Estrella Mountains are located to the southwest of the study area and have an elevation of 3,320 feet above MSL. On the western boundary, the White Tank Mountains rise to an elevation of 4,026 feet above MSL. On the eastern boundary, the Superstition Mountains rise to an elevation of 4,620 feet above MSL[7].

1.2 Location of Meteorological and Air Quality Monitoring Sites

Air quality monitoring networks operate in urban and rural areas throughout Arizona. ADEQ and MCAQD continually monitor and assess air quality in the metropolitan centers, as well as in more remote areas of the state. There are 20 PM-10 monitoring stations in the Maricopa County PM-10 nonattainment area. MAG has analyzed the air quality data from these monitors for March 2005 to March 2006. During this period, the Buckeye, Durango Complex, Greenwood, Higley, and West 43rd Avenue monitors exceeded the 24-hour PM-10 standard. Most of the exceedances occurred at Durango Complex and West 43rd Avenue which are located in the Salt River Study Area. Figure 1-1 shows the location of the PM-10 monitoring sites in or near the nonattainment area[2].

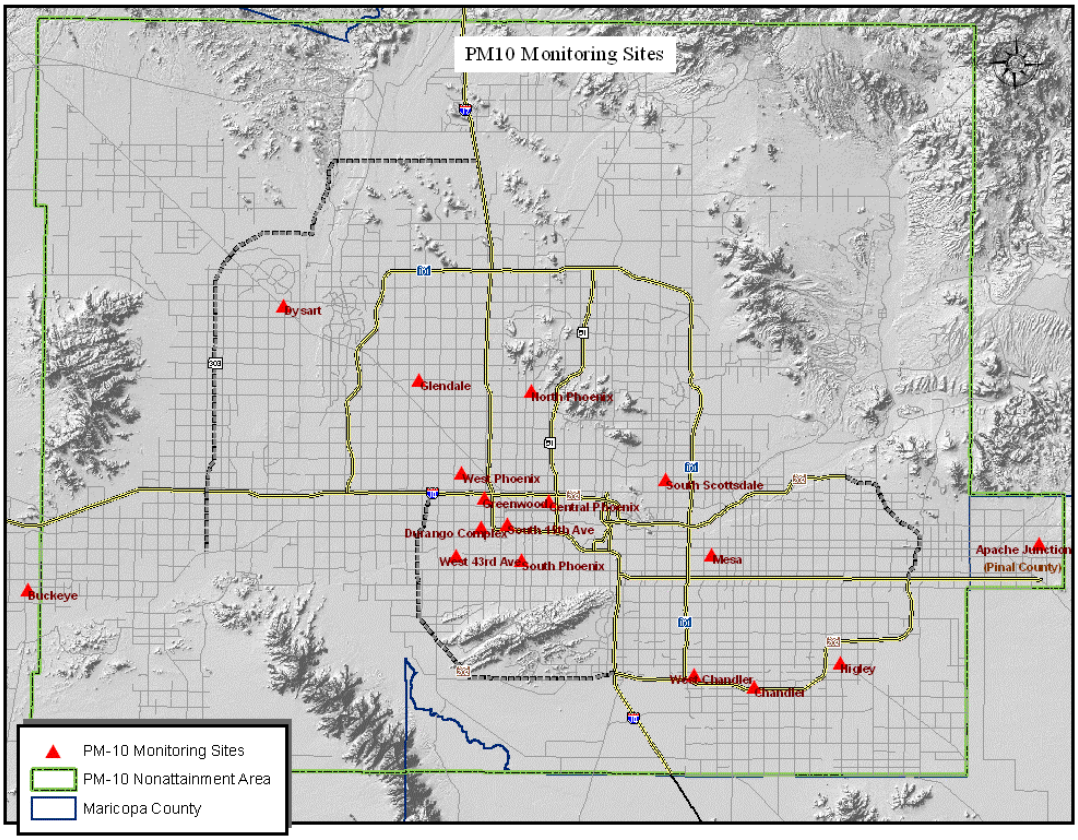

Figure 1-1 PM-10 Monitoring Sites In or Near the Maricopa County PM-10 Nonattainment Area as of 12/31/2005

1.2.1 Durango Complex

This monitor began operation on January 6, 1999. Continuous co-located PM-10 and PM-2.5 monitors currently operate at this site. Instruments that measure wind speed/direction and atmospheric pressure are also located at Durango[3].

Figures 1-2, 1-3, and 1-4 show the satellite imagery around the Durango Complex monitor at elevations of 6,462 feet, 34,493 feet, and 18.2 miles, respectively. All of the satellite photos were taken in December 2005. Figure 1-5 shows the 36-hour backward trajectory analysis at the Durango Complex monitor on December 12, 2005 conducted at heights of 10m, 100m and 800m. The backward trajectory analysis was done using the NOAA HYSPLIT model. The start time for the analysis was 07:00 a.m. UTC on December 12, 2005. EDAS 40km meteorological data was used.

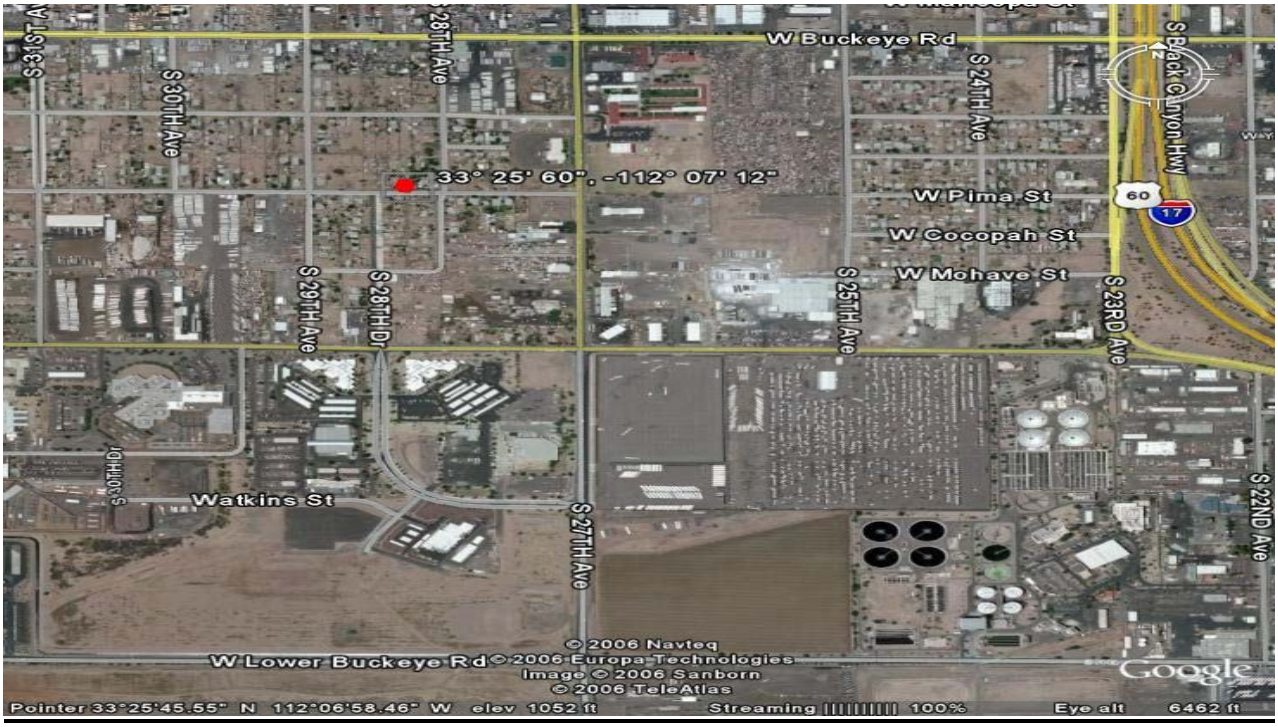

Figure 1-2 Satellite Imagery around Durango Complex (Red Dot) at 6,462 ft

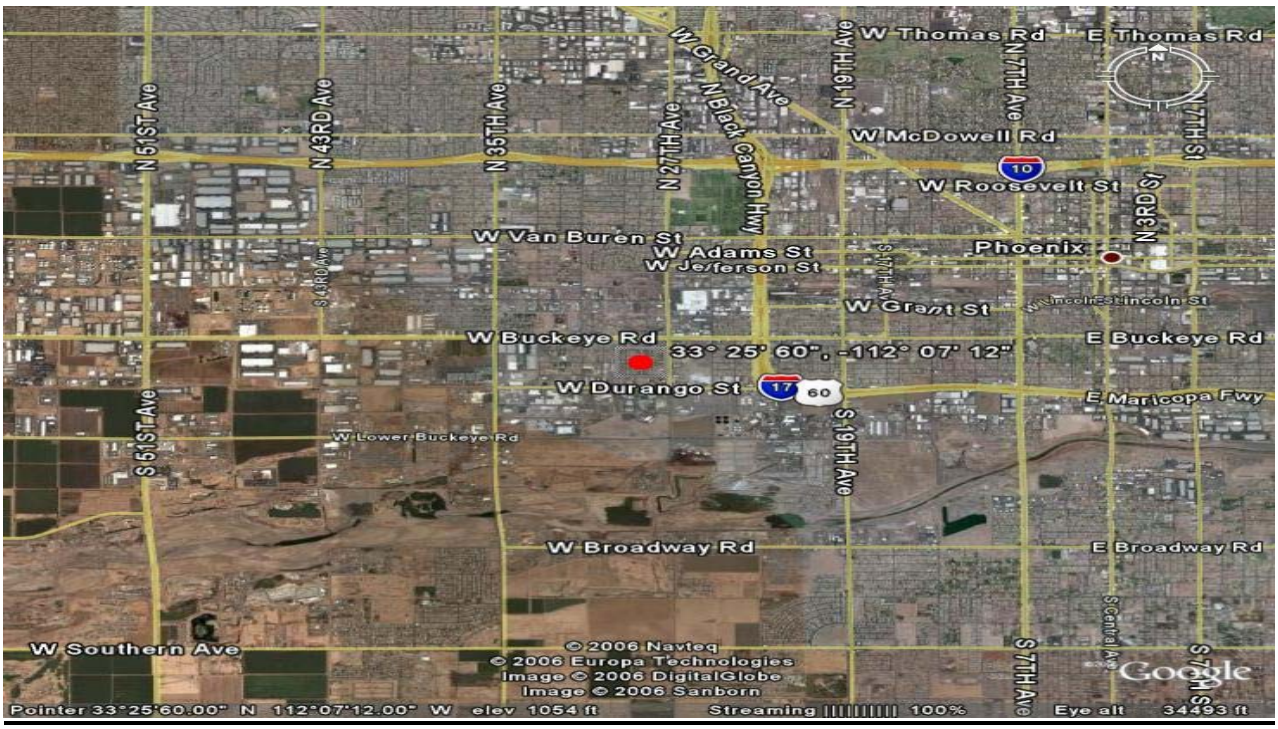

Figure 1-3 Satellite Imagery around Durango Complex (Red Dot) at 34,493 ft

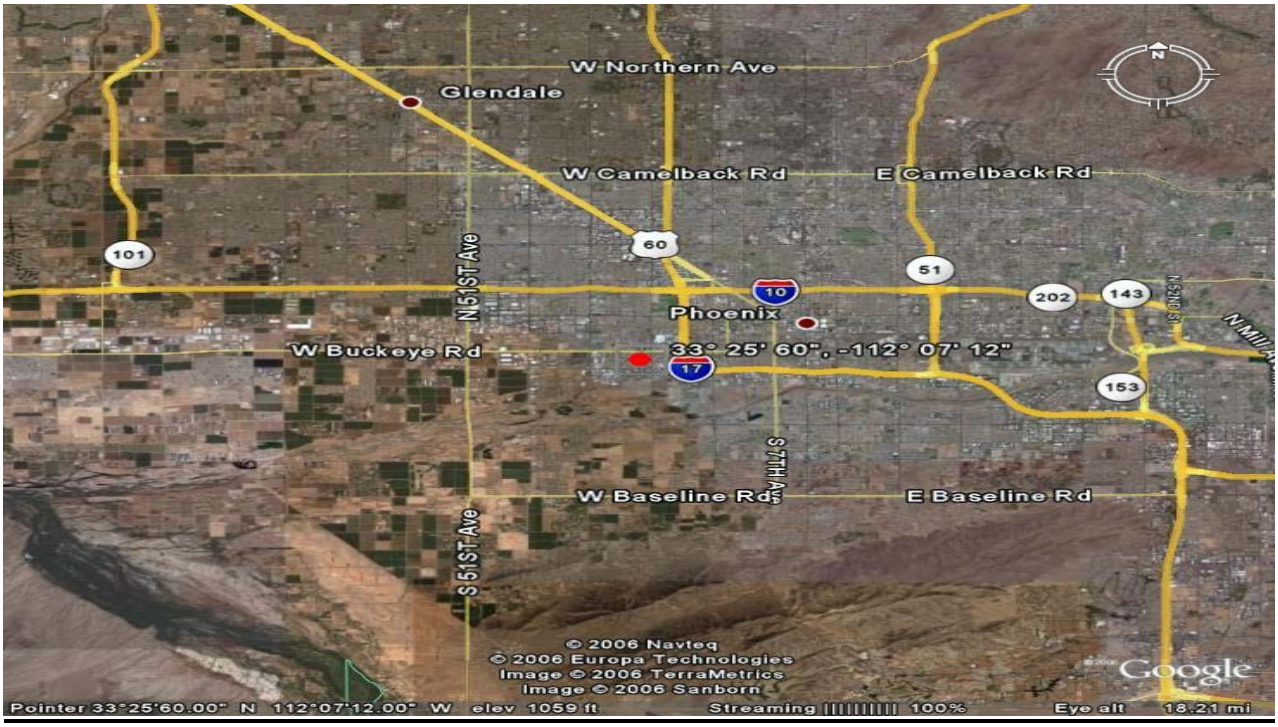

Figure 1-4 Satellite Imagery around Durango Complex (Red Dot) at 18.2 miles

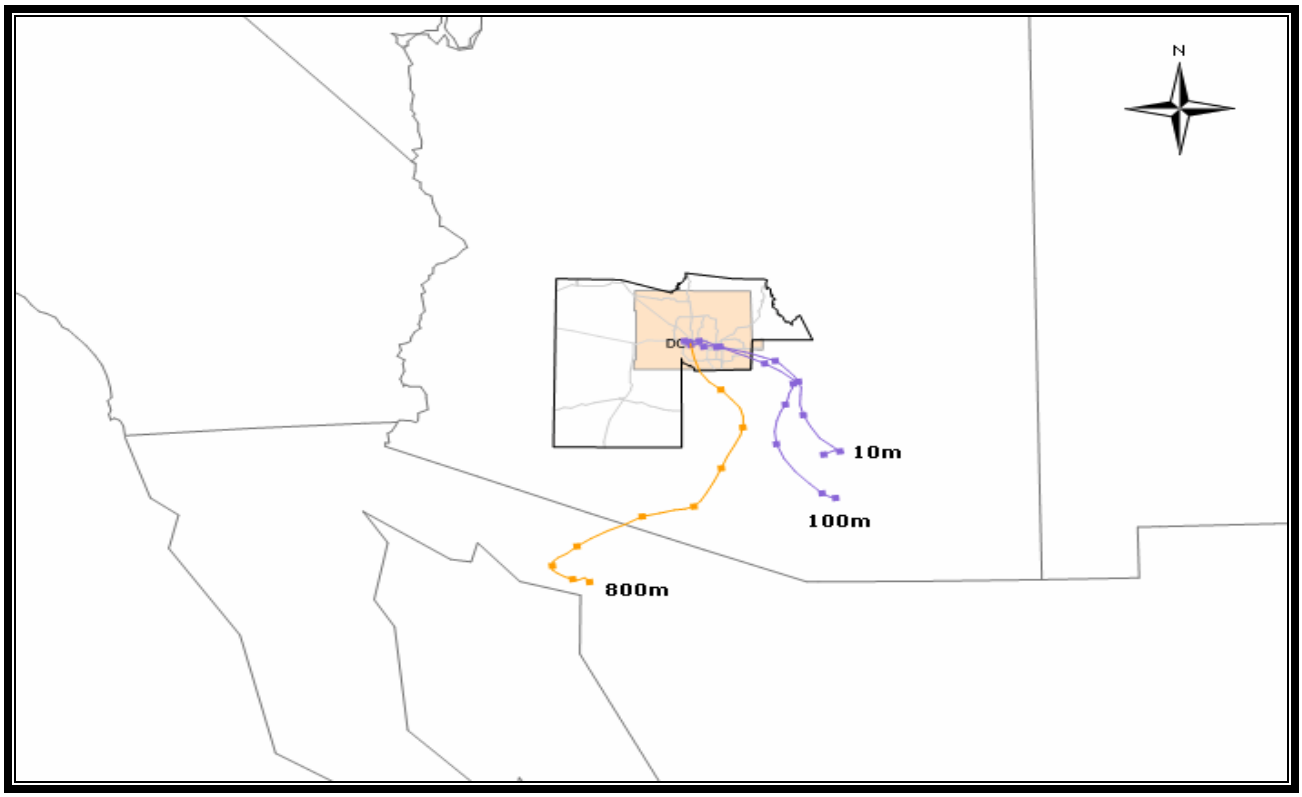

Figure 1-5 Backward Trajectories for December 12, 2005 – Durango Complex

1.2.2 West 43rd Avenue

This monitoring site is surrounded by a combination of heavy industry and residential homes. The site has one continuous TEOM PM-10 monitor and a temperature inversion instrument. The main purpose of the monitor is to measure maximum concentrations of PM-10 and determine the impact on ambient pollution levels of significant sources or source categories[3]. The sources around the site include sand and gravel operations, auto and metal recycling, landfills, paved and unpaved haul roads, and cement casting. Figures 1-6, 1-7 and 1-8 show the satellite imagery around the West 43rd Avenue monitor captured at elevations of 10,298 feet, 20,176 feet and 10.1 miles, respectively. All of the satellite photos were taken in December 2005.

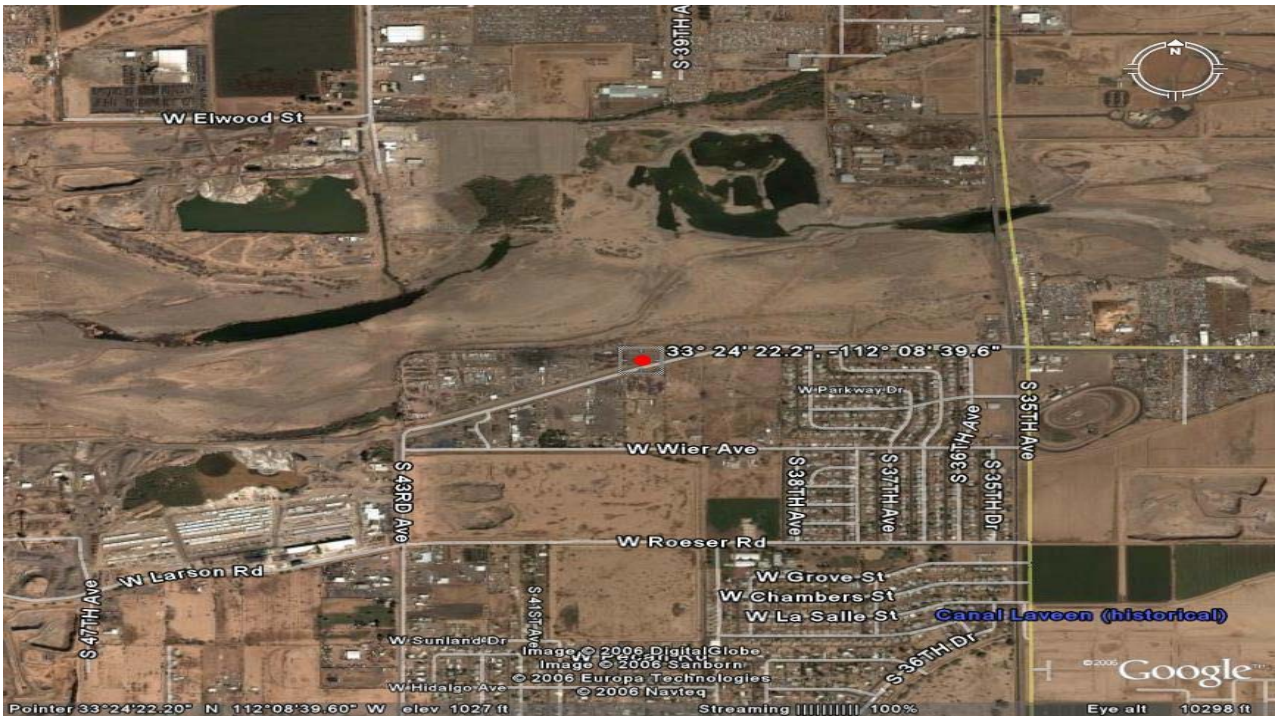

Figure 1-6 Satellite Imagery around West 43rd (Red Dot) at 10,298 ft

Figure 1-7 Satellite Imagery around West 43rd (Red Dot) at 20,176 ft

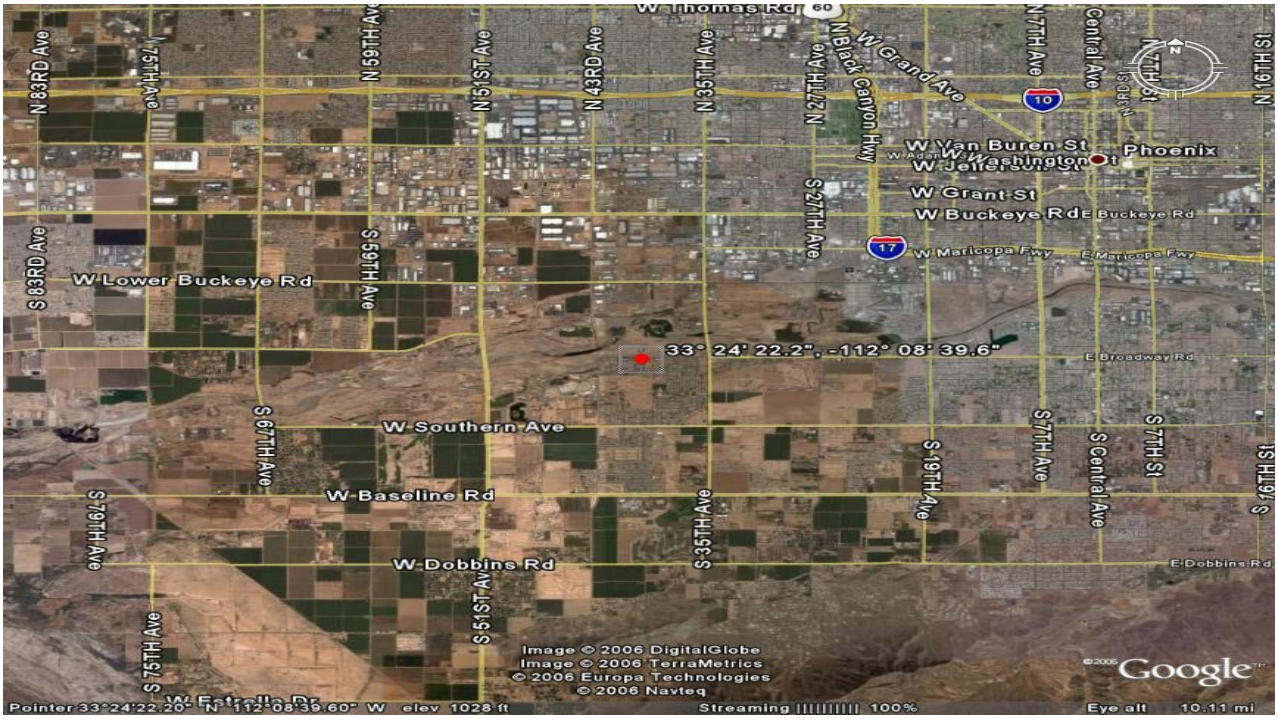

Figure 1-8 Satellite Imagery around West 43rd (Red Dot) at 10.1 miles

1.2.3 Higley

In 1994, ADEQ set up this site to monitor background particulate concentrations near the urban limits of Maricopa County. Since then, urban expansion has enveloped the site, so the monitor no longer serves its original intended purpose. MCAQD installed a (1-in-6 day) PM-10 (SLAMS) in the second quarter of 2000. On October 1, 2004, the 1-in-6 day PM-10 monitor was replaced with an hourly continuous PM-10 monitor[3]. Figures 1-9, 1-10 and 1-11 show the satellite imagery around the Higley monitor at elevations of 6,152 feet, 12,013 feet, and 26,569 feet, respectively. All of the satellite photos were taken in December 2005. Figure 1-12 shows the 36-hour backward trajectory analysis at the Higley monitor on January 24, 2006 taken at heights of 10m, 100m and 800m. The backward trajectory analysis was done using the NOAA HYSPLIT model. The start time for the analysis was 07:00 a.m. UTC on January 24, 2006. EDAS 40km meteorological data was used.

Figure 1-9 Satellite Imagery around Higley (Red Dot) at 6,152 ft

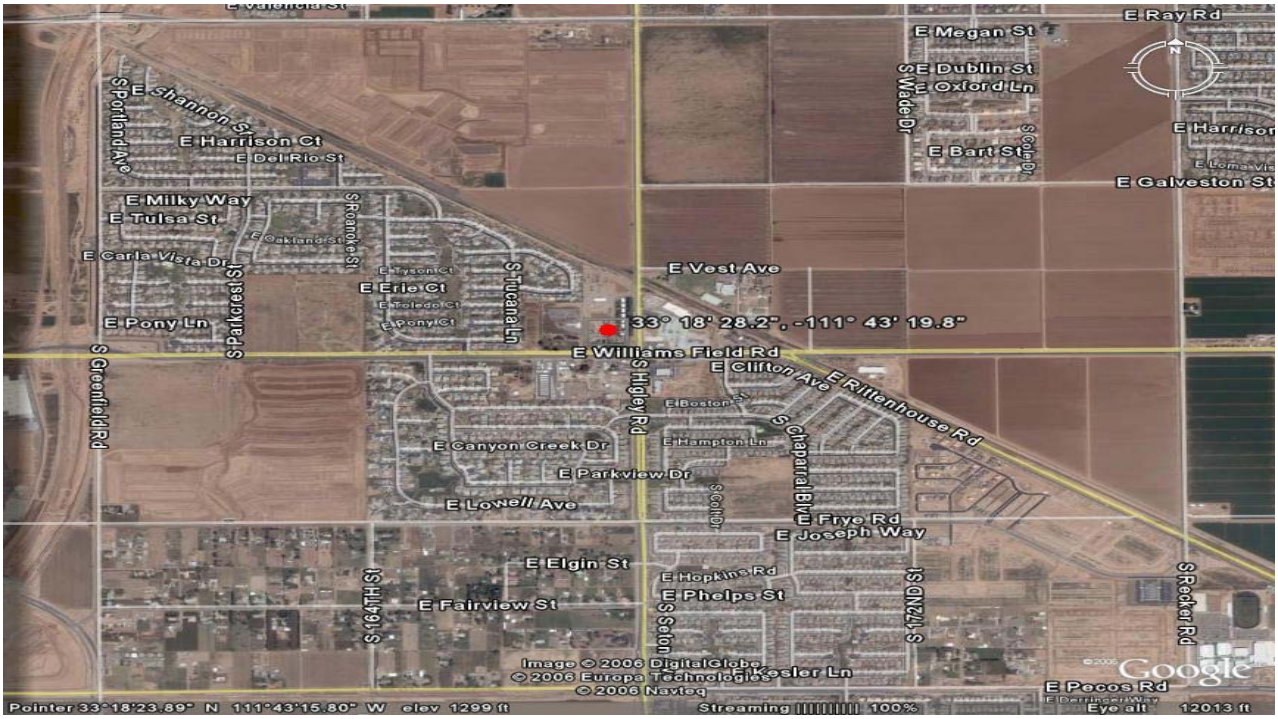

Figure 1-10 Satellite Imagery around Higley (Red Dot) at 12,013 ft

Figure 1-11 Satellite Imagery around Higley (Red Dot) at 26,959 miles

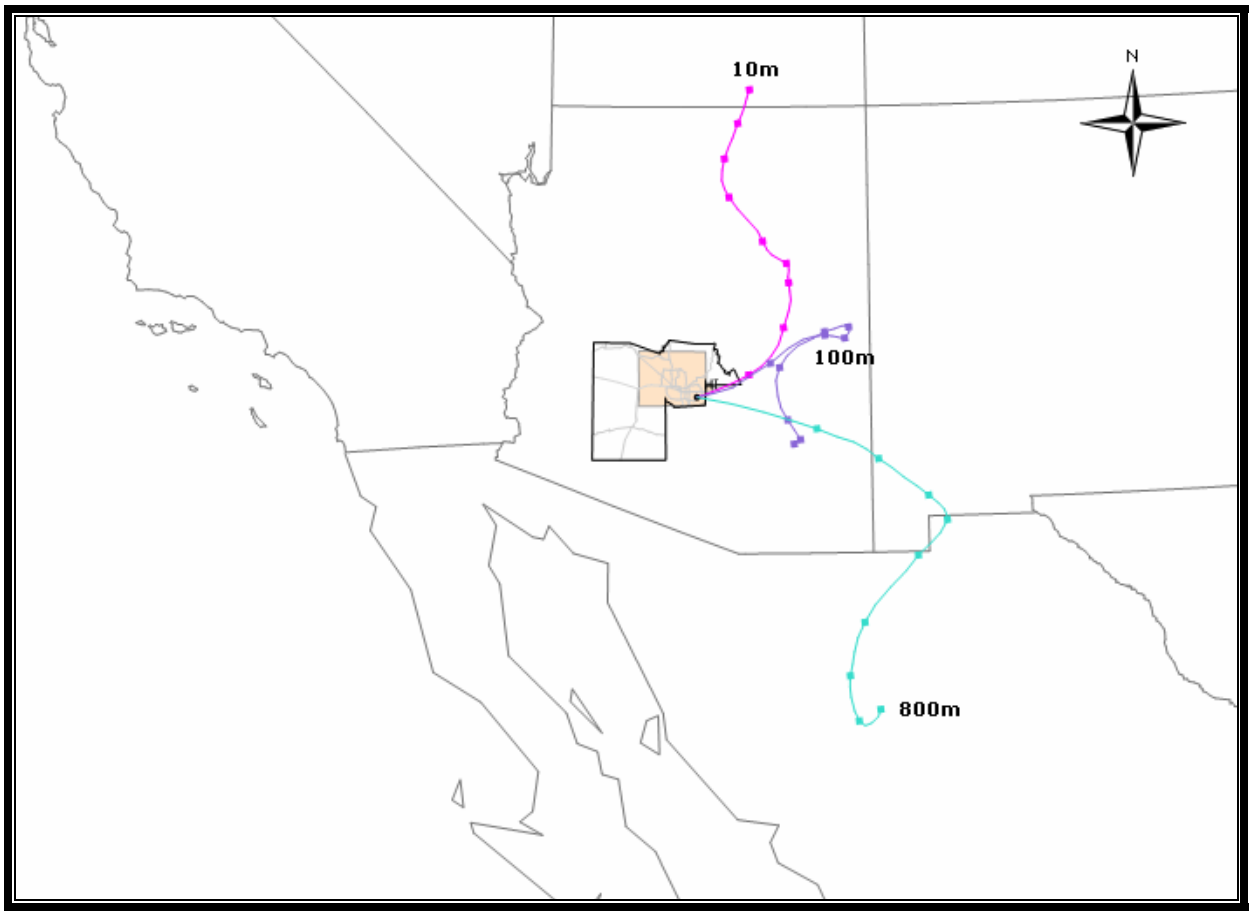

Figure 1-12 Backward trajectory for January 24, 2006 – Higley

1.3 Distribution of Major Emissions Sources

The major PM-10 emissions sources in the Maricopa County nonattainment area are:

- Agricultural land
- Alluvial channels
- Construction areas
- Miscellaneous disturbed areas
- Paved roads
- Unpaved roads
- Unpaved shoulders
- Unpaved parking lots
- Surface mining
- Vacant lots

Figure 1-13 shows 2002 annual average daily PM-10 emissions, based on the latest MCAQD periodic emissions inventory[9]. The distribution of emissions

sources surrounding each monitor varies widely. In the ADEQ Salt River Area PM-10 Study, the emissions sources for a 37 square mile area were inventoried for the year 2002. As mentioned previously, the Bethune Elementary, Durango Complex, South Phoenix, and West 43rd Avenue monitors are located in the Salt River Study Area. 2002 PM-10 emissions sources for low and high wind days from the Salt River Study Area are shown in Figures 1-14 and 1-15[1]. Figure 1-16 shows the comparable land use patterns in the Salt River Area in 2002.

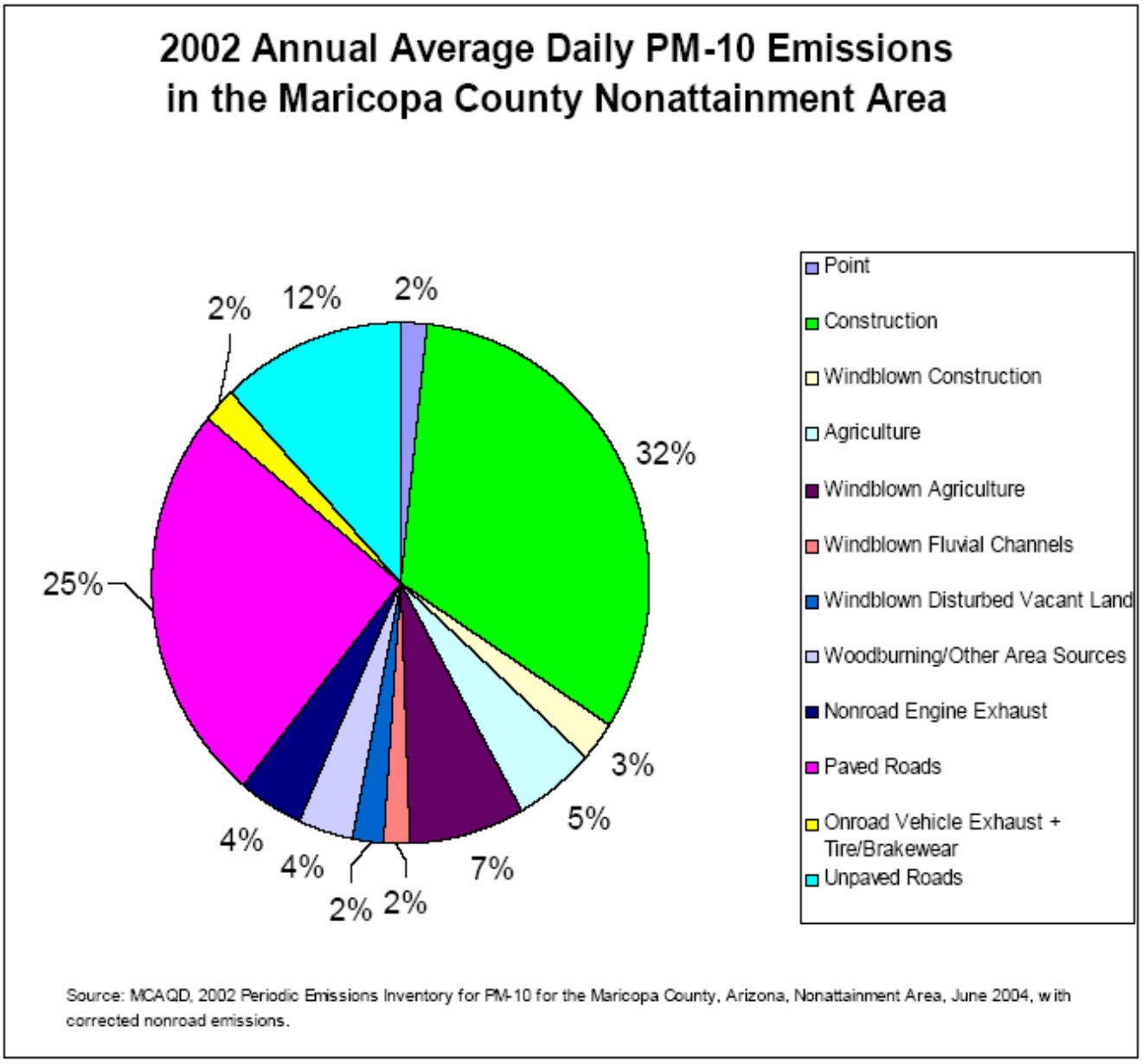

Figure 1-13 2002 Annual Average Daily PM-10 Emissions

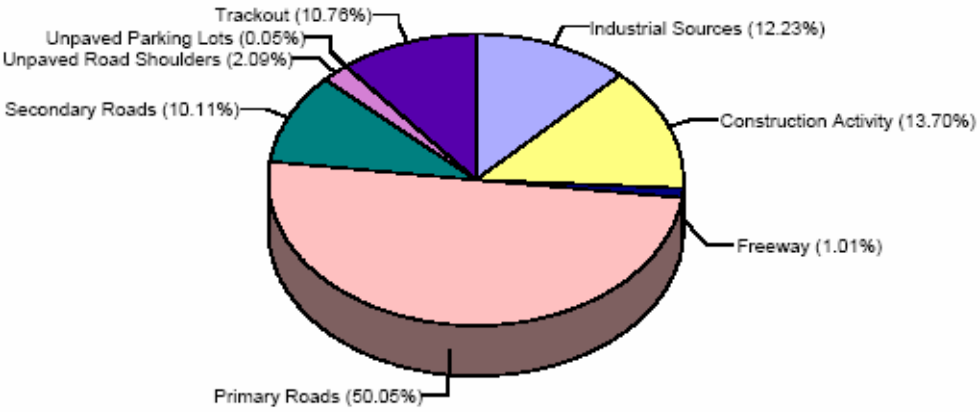

Figure 1-14 Salt River Area PM-10 Emissions on December 16, 2002 (Low Wind Day)[1]

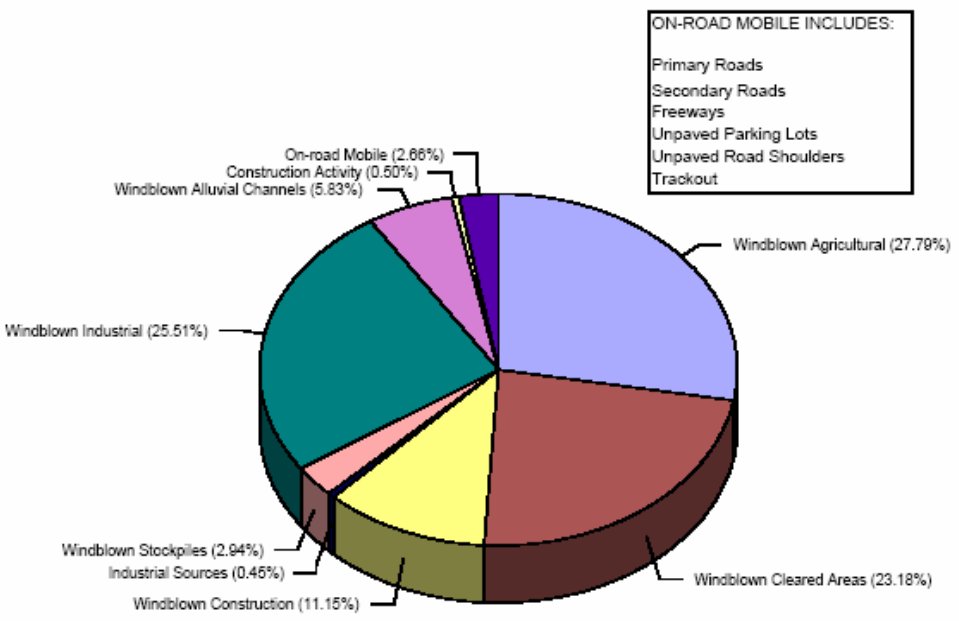

Figure 1-15 Salt River Area PM-10 Emissions on April 15, 2002 (High Wind Day)[1]

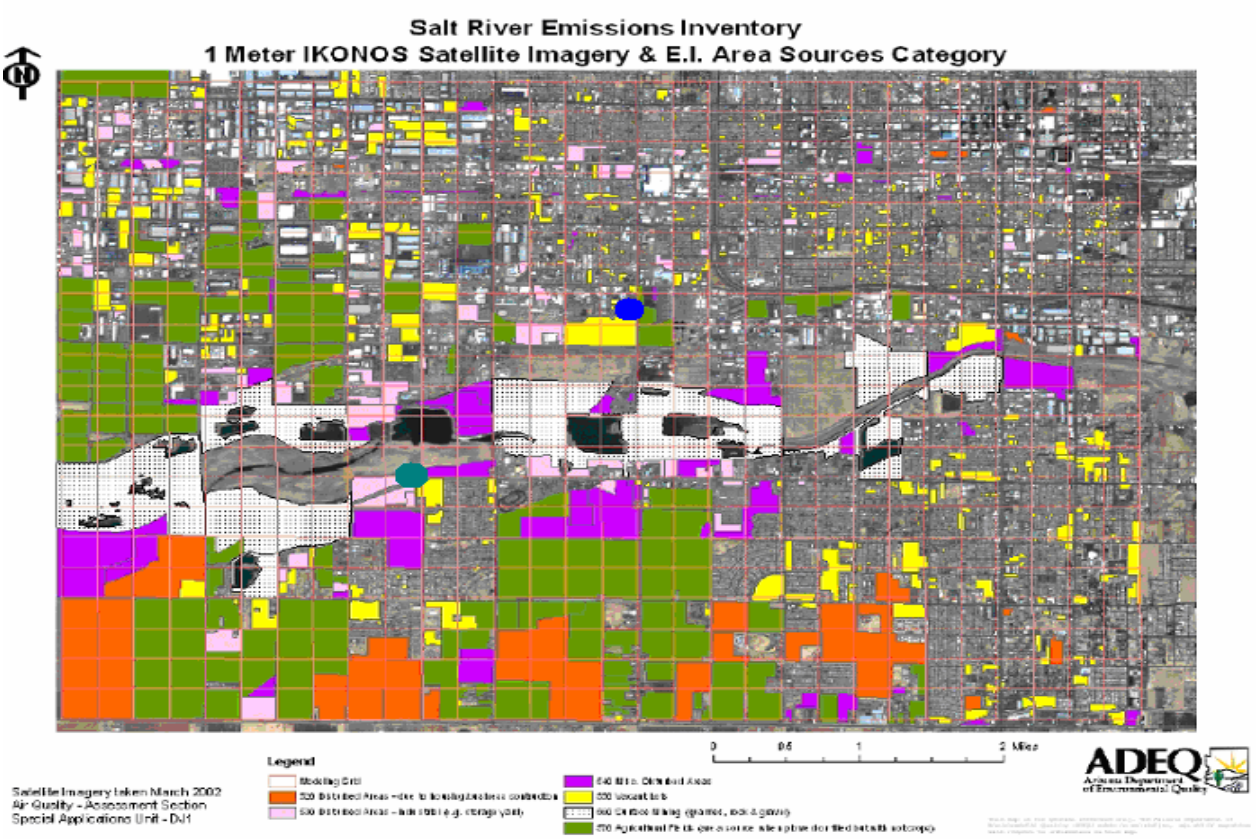

Figure 1-16 2002 Land Use Data for the Salt River Study Area[1]

1.4 Deposition and Concentration of Pollutants

Dry deposition is frequently characterized as being analogous to resistance in an electrical circuit. The flux to the ground is assumed to be equal to the concentration measured at a given height multiplied by the mass transfer coefficient, which is also dependent on height. The mass transfer coefficient is called the deposition velocity[8]. Aerosol deposition velocity calculated by grid models and observation is shown in Figure 1-17[6]. The HYSPLIT model developed by NOAA provides predictions of concentrations and deposition (both wet and dry) of both gaseous and particulate pollutants[4]. To understand the dry deposition and concentration of particulate pollutants over a specified point on design days, HYSPLIT4 was run. The results are presented in Figures 1-18 to 1-21.

The concentration of particulates was calculated considering the various HYSPLIT modeling options. Particle diameter was assumed to be greater than or equal to 1um and density equal to 1 g/cc. The 24-hour layer average concentration was calculated based on the mixing height on these respective days with the top height of the pollutant source set at 25 meters.

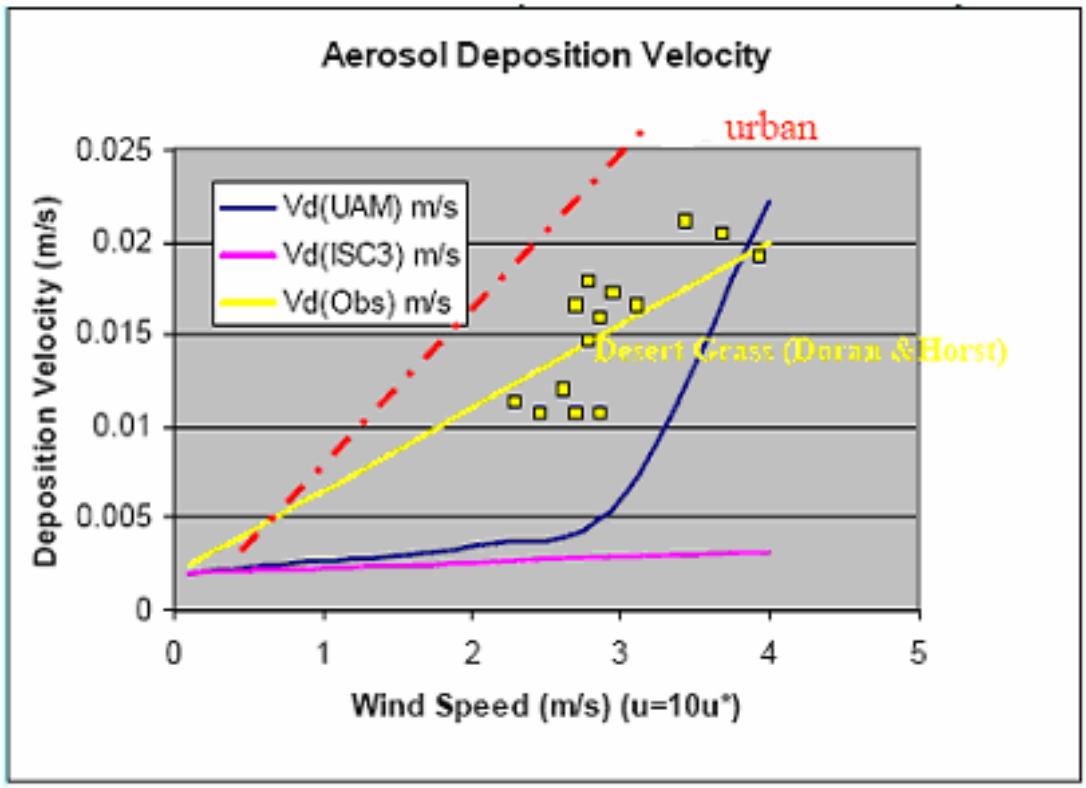

Figure 1-17 Aerosol Deposition Velocity by Grid Models and Observation[6]

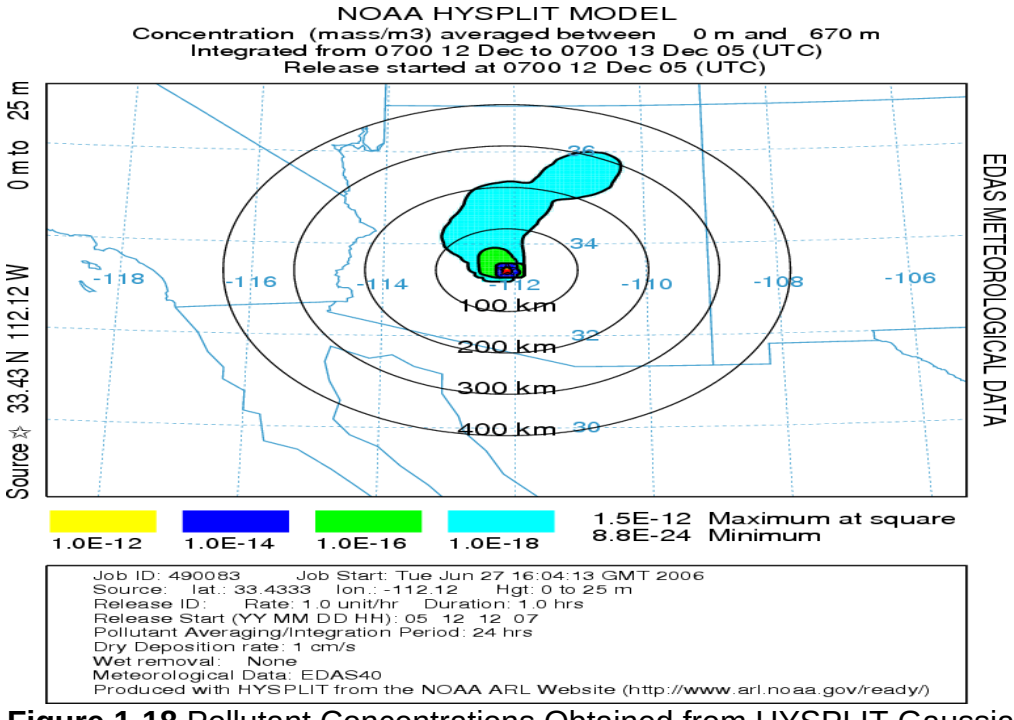

Figure 1-18 Pollutant Concentrations Obtained from HYSPLIT Gaussian Plume Model for December 12, 2005

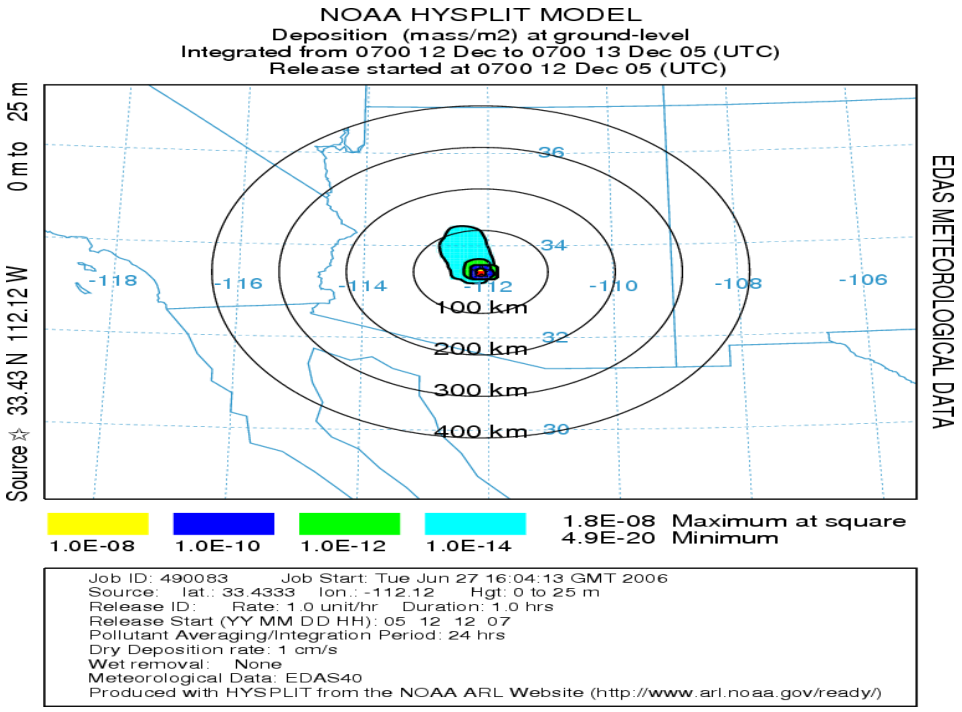

Figure 1-19 Dry Deposition Obtained from HYSPLIT Gaussian Plume Model for December 12, 2005

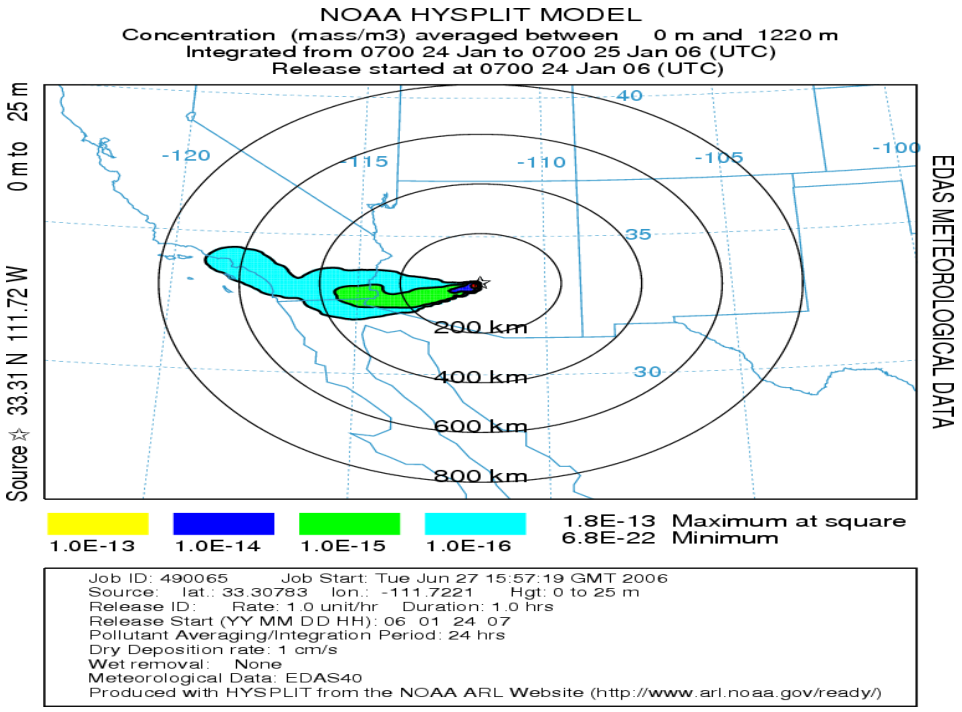

Figure 1-20 Pollutant Concentrations Obtained from HYSPLIT Gaussian Plume Model for January 24, 2006

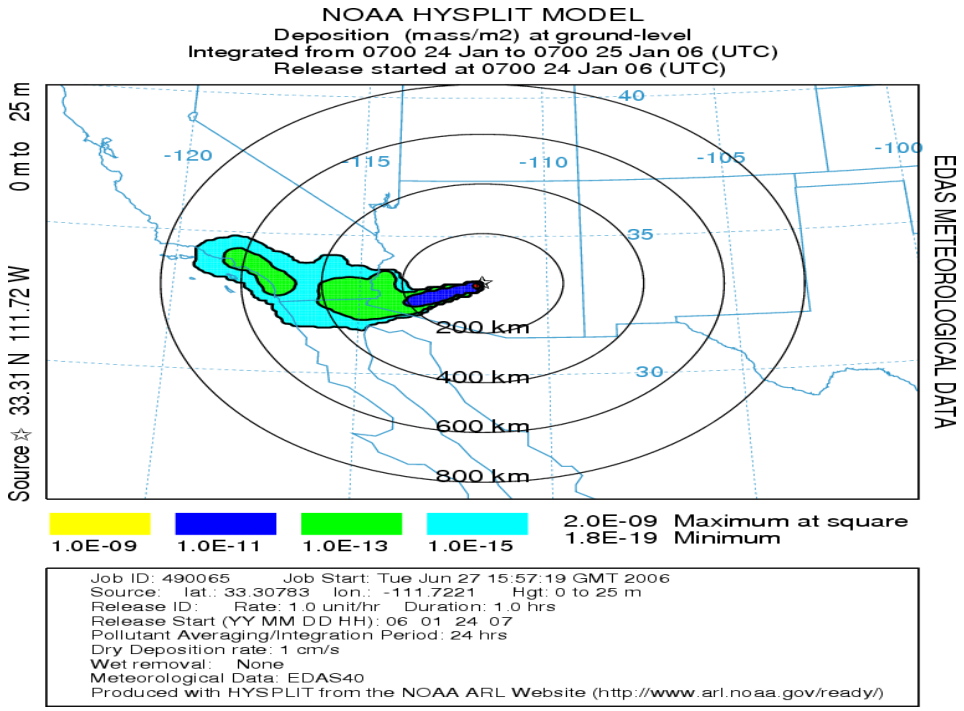

Figure 1-21 Dry Deposition Obtained from HYSPLIT Gaussian Plume Model for January 24, 2006

Dry deposition calculations are performed in the lowest model layer based upon the relationship that the deposition flux equals the velocity times the ground-level air concentration. This calculation is available for gases and particles. The dry deposition velocity can be set directly for each pollutant by entering a non-zero value in the first field. The dry deposition rate considered is 1 cm/s[4].

1.4.1 December 12, 2005

On December 12, 2005, a stagnant day, the HYSPLIT data in Figure 1-5 indicates that there were light southwesterly winds. Figures 1-18 and 1-19 confirm that the pollutant concentrations and dry deposition on this low wind day were predominantly of local origin. Wind speeds on this day averaged 1.6 mph and the highest hourly wind speed of 3.6 mph occurred between 11 p.m. and 12 midnight at the West 43rd Avenue site. Similar wind speed data were observed at the Durango Complex, Greenwood and West Phoenix stations.

1.4.2 January 24, 2006

Figure 1-12 shows the 36-hour backward trajectory on January 24, 2006. On this high wind day, the winds aloft (800m) originated in the southeast, with lower level winds from the east and northeast. The analysis of monitoring data on January 24, 2006 at Higley reveals that the PM-10 exceedances were caused by

high easterly winds. Wind speeds on this day averaged 7.6 mph. The highest hourly wind speed of 16.9 mph occurred between 1 and 2 p.m., with the second high between 2 and 3 p.m. at 16.1 mph. Since there were two hours with wind speeds exceeding 15 mph, this day qualifies as high wind. Figures 1-20 and 1-21 show that the areas of highest pollutant concentrations and deposition on this high wind day were much larger than the Maricopa County PM-10 nonattainment area and the impacted areas extended westward all the way to Southern California.

1.5 Previous PM-10 Studies

Two previous PM-10 studies results were considered in evaluating the air quality modeling domains:

- PM-10 SIP for the Salt River Area, ADEQ[1]
- PM-10 modeling using CMAQ, ASU[5]

1.5.1 PM-10 SIP for the Salt River Study Area

In this ADEQ Plan, the elevated PM-10 concentrations in the Salt River Study Area were simulated using the Industrial Source Complex Short Term (Version-3) (ISCST-3). Contributions to overall PM-10 in the domain were predicted using separate, day specific source category emissions files. The modeling domain consisted of an array of 400 x 400 meter grids, 30 in the east-west (EW) direction and 21 in the north-south (NS) direction, for a total of 630 grids. The dimensions of the array were 7.5 miles (12 kilometers) EW and 5.2 miles (8.4 km) NS. The study domain includes four monitors, the major industrial activities in the area, an expansive area of active agricultural land, and active residential construction sites.

1.5.2 PM-10 Modeling using CMAQ, ASU

High (episodic) particulate matter (PM) events over the sister cities of Douglas (AZ) and Agua Prieta (Sonora), located on the US-Mexico border, were simulated by Arizona State University using the 3D Eulerian air quality model, MODELS3/CMAQ. Best available input information was used for the simulations. In spite of the inherent uncertainties in the emissions inventories, chemistry and meteorology, the CMAQ model evaluations showed acceptable results. The CMAQ modeling domain was nested down from a coarse 36 km grid resolution directly to the fine-grid domain of 0.5 km grid resolution. Sensitivity studies on the role of boundary conditions indicate insignificant regional contributions, as well as trivial contributions of secondary particles to the occurrence of high PM events in the study area. High PM episodes in the study area, therefore, are local events that largely depend on local meteorological conditions. The major PM emission sources were identified as vehicle activities on unpaved/paved roads and wind-blown dust. The study concluded that there is a need for modifications to

MODELS3/CMAQ to allow more interaction between meteorology and emissions, which is currently absent in dealing with particulate matter.

1.6 Modeling Domains

All of the above factors were considered in determining the size of the modeling domains to be used with AERMOD and rollback. Based on these factors, MAG is proposing that a much larger modeling domain be defined for the Durango and West 43rd monitors than for the monitor outside the Salt River Study Area that exceeded the standard (i.e., Higley).

1.6.1 AERMOD Modeling Domain – Salt River Study Area

The Durango Complex and West 43rd Avenue monitors are located within 2 miles of each other (as the crow flies) and share many common emissions sources. It is recommended that modeling for the Five Percent Plan build upon the 2002 emissions inventory work done by ADEQ in the Salt River Area PM-10 Study[1]. In the ADEQ Study, the modeling domain consisted of an array of 400x400 meter grids, 30 east-west and 21 north-south, for a total of 630 grids. A smaller grid size may be considered if emissions inventory updates and monitoring in the Salt River Study Area during the fall of 2006 indicates that this would improve the accuracy of the AERMOD model. The dimensions of the grid array are 7.5 miles by 5.2 miles, an area of approximately 37 square miles. The domain includes the two monitors that recorded the highest PM-10 concentrations on December 12, 2005, as well as the Bethune Elementary and South Phoenix monitors. It is proposed that this domain be used to model PM-10 concentrations with AERMOD on December 11-13, 2005.

1.6.2 Rollback Modeling Domain - Higley

The Higley monitor is located at the southeast corner of the PM-10 nonattainment area. As indicated in Figures 1-14 through 1-16, the predominant sources of PM-10 to the north and east of the Higley monitor are vacant lands under development or used for agricultural purposes. The analysis of monitoring data on January 24, 2006 at Higley reveals that the PM-10 exceedances were caused by high easterly winds. Wind speeds on this day averaged 7.6 mph. The highest hourly wind speed of 16.9 mph occurred between 1 and 2 p.m. The average between 2 and 3 p.m. was 16.1 mph. Since there were two hours with wind speeds exceeding 15 mph, this day qualifies as a high wind day.

Due to the limited number and type of emissions sources contributing to elevated PM-10 concentrations at the Higley monitor, it is proposed that the rollback model be applied with a domain size of 2 km x 2 km. Prior studies performed by ADEQ and Clark County, Nevada, will be examined to determine the distance of influence for PM-10 sources. In addition, field work being performed by the MAG PM-10 Source Attribution and Deposition Study in the fall of 2006 will provide

additional insights into PM-10 deposition rates in the nonattainment area. The size of the modeling domain for the Higley monitor may be increased if these studies and/or aerial and satellite imagery and meteorological data indicate that there are significant contributing sources outside of the 2 km x 2 km modeling area.

REFERENCES

[1] Revised PM-10 State Implementation Plan for the Salt River Area, Technical Support Document, ADEQ, June 2005

[2] 2005 Air Monitoring Network Review, Maricopa County Air Quality Department, May 2006

[3] HYSPLIT User's Guide, version 4.8, June 2006

[4] Modeling of episodic particular matter events using a 3-D air quality model with fine grid: Applications to a pair of cities in the U.S./Mexico border , Yu-Jin Choi*, Peter Hyde[+], and H. J. S. Fernando*, *Environmental Fluid Dynamics Program, Department of Mechanical and Aerospace Engineering, Arizona State University, Tempe, AZ 85285, [+]Arizona Department of Environmental Quality, Phoenix, AZ 85102, USA, Submitted to Atmospheric Environment, November 15, 2005

[5] Particulate Transport between the Utah and Salt Lake Valleys, John Watson and Dan Freeman, Desert Research Institute, September 2001. (http://www.pnl.gov/VTMX/WatsonFreeman2001.html)

[6] Road Dust is Overestimated in Air Quality Grid Models, Yayi Dang, Rick Hardy, Mike McGown, Idaho DEQ, October 2004.

[7] Revised MAG 1999 Serious Area Particulate Plan for PM-10 for the Maricopa County Nonattainment Area, Maricopa Association of Governments, February 2000

[8] Field Testing and Evaluation of Dust Deposition and Removal Mechanisms: Final Report, Desert Research Institute, January 2003

[9] 2002 Periodic Emission Inventory for PM-10 for the Maricopa County, Arizona, Nonattainment Area, Maricopa County Air Quality Department, June 2004